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Poling Effect in "Morphotropic" PZN-9%PT Crystals by Powder Diffraction

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Introduction: The piezoelectric system $Pb(Zn_{1/3}Nb_{2/3})_{1-x}Ti_xO_3$, known as PZN-x%PT, is being considered for the next generation of electromechanical transducers[1]. The rhombohedral (R3m) single crystals show remarkable piezoelectric properties when poled along the <100> directions. The reason for this unusual behavior can be understood by the existence of a lower symmetry phase close by in the phase diagram which can be easily induced by the electric field, as earlier observed in $PbZr_{1-x}Ti_xO_3$, a prototype piezoelectric [3]. In the case of PZN-x%PT, this symmetry is found to be orthorhombic [3-4]. The orthorhombic unit cell can be considered as a primitive monoclinic Pm cell in the limit of $a_m=c_m$. Indeed, under the application of an electric field the true monoclinic phase is induced ($a_m \neq c_m$) and the polarization rotates between [101] and [001], in the monoclinic plane producing very large electromechanical deformations[5].

Methods and Materials: The observation of these distortions is not easy, mainly due to the fact that these ferroelectric relaxors are intrinsicaly disordered. However, a relaxor-to-ferroelectric phase transition can be induced by poling the crystals under an electric field. In these experiments we have performed high-resolution diffraction from powders made by lightly crushing two small pieces of a poled PZN-%9PT single crystal. One of the pieces was taken from underneath the electrode area (poled) while the other one was taken from outside the electrode area (unpoled) of the same crystal.

Results and conclusions: As shown in Fig. 1, the diffraction patterns look quite different in both cases. The poled sample shows extraordinary sharp peaks, while the unpoled sample shows broad peaks indicative of its disorder character. However a careful analysis shows that the underlying symmetry is the same, orthorhombic, in both cases. We show that careful poling and comparison of poled/unpoled samples can be very useful in the characterization of low symmetry distortions in disordered relaxor piezoelectric systems, where the peak broadening can make this task extremely difficult.

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References: [1] S.E. Park and T. Shrout J. Appl. Phys.82, 1804 (1997); [2] B. Noheda et al., App. Phys. Lett. 74,2059 (1999); [3] D.E. Cox. et al. Appl. Phys. Lett. 79, 400 (2001); [4] 4. D. La-Ourattapong et al., (submitted). <cond-mat/0108264>; [5] B. Noheda et al., Phys. Rev. Lett. 86, 3891 (2001)

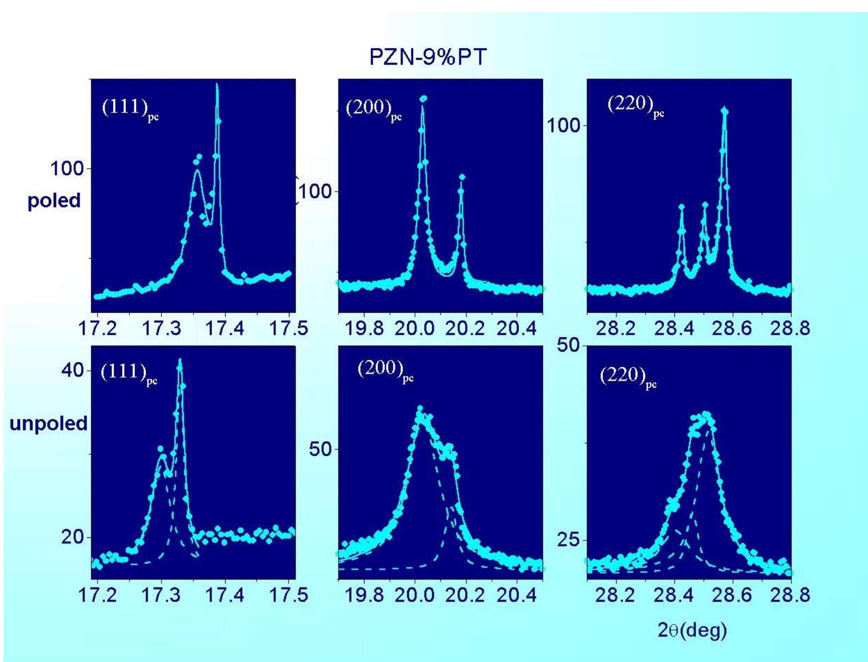

Figure 1: Pseudo-cubic (111), (200) and (220) reflections in the relaxor PZN-9%PT poled (top) and unpoled (bottom). The solid symbols are the experimental points and the solid lines are Lorentzians fits. In the unpoled case, the individual peaks in the fits are also included as dashed lined.